Incidence and Risk Analysis of Surgical Site Infection in Spine Surgery Patients in an Outpatient *versus* Hospital Cohort

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ABSTRACT

Objective: *Surgical site infection (SSI) is a well-documented cause of patient morbidity, with an associated increase in cost to the healthcare system. The move to outpatient surgery is to reduce the overall cost of surgery in conjunction with improved patient morbidity. The authors aim to determine the incidence of SSIs in the outpatient setting and associated risk factors. This information will prove to be invaluable to overall patient care.*

Methods: *The databases of 2205 spinal procedures performed over 10 years by a single surgeon were reviewed. Two groups were created; Group 1 patients with procedures performed in the hospital setting and Group 2 patients with procedures performed in the ambulatory surgery centre. Excluded cases were patients under 18 years old, acute trauma and minor orthopaedic procedures. Included cases were cervical fusions, disc replacement and lumbar decompressions with or without fusion. Outcomes assessed included; age, body mass index (BMI), surgeon time and estimated blood loss (EBL). Relative risk factors such as BMI, smoking, alcohol use and a number of spinal levels operated on were also assessed as independent risk factors for SSIs.*

Results: *There were 1010 included cases, 642 in a hospital setting and 368 in an outpatient setting. Mean age and BMI were 53 ± 0.5 years and 28.3 ± 0.3 kg/m^2, respectively, with no intergroup significance. Surgical times of 217 ± 11 minutes and 117 ± 8 minutes and EBL of 323 ± 33 mL and 73 ± 8 mL demonstrated significance ($p = 0.001$) between the hospital and outpatient group. The overall incidence of SSIs was 1.6% and there was a significant intergroup difference, $p = 0.045$. Obesity and multilevel surgeries proved to be significant independent risk factors, $p = 0.005$ and $p = 0.01$, respectively. Smoking had the highest relative risk 10.9 and was also significant, $p = 0.02$.*

Conclusion: *Incidence rate of SSIs in this study showed significant difference between inpatient and outpatient setting. Modifiable risk factors such as weight, smoking, alcohol use and numbers of levels necessary for operation should be considered. This will impact preoperative patient selection, the procedure required and allow for a decrease in SSI risk.*

Keywords: Incidence, inpatient, less exposure surgery, outpatient, risk analysis, surgical site infections

Análisis de la incidencia y riesgo de infección del sitio quirúrgico en pacientes de cirugía de columna vertebral en una cohorte ambulatorio frente a una hospitalaria

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RESUMEN

Objetivo: *Infección del sitio quirúrgico (ISQ) es una causa bien documentada de morbilidad de los*

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pacientes, asociada a un aumento en el costo del sistema de salud. El paso a la cirugía ambulatoria va encaminado a reducir el costo general de la cirugía en conjunto y producir a la vez una mejoría en relación con la morbilidad de los pacientes. Los autores persiguen determinar la incidencia de la ISQ, así como los factores de riesgo asociados, en el contexto ambulatorio, obteniendo se ese modo una información valiosa para el cuidado general del paciente.

Métodos: *Se revisaron las bases de datos de 2205 procedimientos espinales realizados durante 10 años por un solo cirujano. Se crearon dos grupos: el Grupo 1 formado por pacientes con procedimientos realizados en el recinto hospitalario, y el Grupo 2 formado por pacientes con procedimientos realizados en el centro de cirugía ambulatoria. Se excluyeron los casos de pacientes con menos de 18 años de edad, trauma agudo, o procedimientos ortopédicos menores. Se incluyeron lo casos de fusiones cervicales, reemplazo de disco, y descompresiones lumbares con o sin fusión. Los resultados evaluados incluyeron: edad, índice de masa corporal (IMC), tiempo de cirugía, y pérdida de sangre estimada (PSE). Los factores de riesgo relativo -- tales como índice de masa corporal, hábito de fumar, consumo de alcohol, y número de nivel espinal operado -- también fueron evaluados como factores de riesgo independientes de la ISQ.*

Resultados: *Se incluyeron 1010 casos: 642 en el contexto hospitalario, y 368 en el ambulatorio. La edad media y el IMC fueron 53 ± 0.5 años y 28.3 ± 0.3 kg/m^2, respectivamente, sin ninguna significación intergrupal. Los tiempos quirúrgicos de 217 ± 11 minutos y 117 ± 8 minutos, y la PSE de 323 ± 33 mL y 73 ± 8 mL tuvieron carácter significativo ($p = 0.001$) entre el grupo intrahospitalario y el ambulatorio. La incidencia general de la ISQ fue de 1.6% y hubo diferencias significativas intergrupales,* $p = 0.045$. *La obesidad y las cirugías multiniveles resultaron para ser factores de riesgo independientes significativos,* $p = 0.005$ *y* $p = 0.01$*, respectivamente. El hábito de fumar tuvo el mayor riesgo relativo, 10.9, y fue también significativo,* $p = 0.02$

Conclusión: *La tasa de incidencia de ISQ en este estudio mostró diferencias significativas entre los contextos intrahospitalarios y ambulatorios. Deben tomarse en consideración los factores de riesgo modificables, tales como el peso, el hábito de fumar, el consumo de alcohol, y el número de niveles necesarios para la operación. Esto tendrá un impacto sobre la selección preoperatoria de los pacientes y el procedimiento requerido, a la vez que hará posible que disminuya el riesgo de ISQ.*

Palabras claves: incidencia, intrahospitalario, cirugía de menos exposición, ambulatorio, infección del sitio quirúrgico

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INTRODUCTION

The interest in outpatient spine surgery has surged in recent times. Improvements in technologies and refined surgical techniques have enabled major operations to be offered as less exposure surgery in free standing outpatient surgery centres. Currently, there are over 6000 free standing ambulatory surgery centres (ASCs) in the United States of America [USA] (1, 2) and this number is expected to grow exponentially. It is estimated that by 2016 greater than 50% of all spine surgeries will be done in an outpatient setting. Not surprisingly, this enthusiasm is fueled by reports of faster operations and patient recovery, fewer complications and reduced expenses seen by both patients and healthcare insurers (3, 4). Benefits to surgeons include a safer and more consistent operating team, reliable compensation and better patient outcomes (5, 6).

The literature is saturated with studies focussed on the feasibility, complication rates and patient-reported outcomes for a variety of procedures, most commonly cervical and lumbar decompression and fusion surgeries (7–14). However, there is a paucity of literature on the rate of postoperative surgical site infection (SSI) for cases performed in the ASCs as well as the risk factors associated with SSIs.

Surgical site infections are a devastating and leading cause of both nosocomial infections and unplanned hospital readmission in the USA, resulting in multiple operations, increased hospital stay and healthcare costs (15–17). The reported range of SSIs after adult inpatient elective spine surgery in the hospital setting is between 0.7% and 20% (18–22). Multiple risk factors have been identified which contribute to SSIs after spine surgery which include, increasing age, male gender, body mass index (BMI), metabolic derangements, co-morbidities, smoking and previous surgery (18, 23–27).

In order to substantiate its role in the future of spine surgery, ambulatory surgery centres must demonstrate at a minimum, equivalent and preferably decreased SSI rates than inpatient environments. Herein, a report is provided of the experience of outpatient spine surgery and rates of postoperative SSIs and how these results compare to similar surgeries performed in the hospital setting. The secondary aim was to evaluate the major risk factors for developing postoperative SSIs.

SUBJECTS AND METHODS

We reviewed 2205 spinal procedures from the database of a single spine surgeon between 2004 and 2014. Institutional review board (IRB) approval was granted for the cohort of patients in this study. The primary aim was to determine incidence of postoperative SSIs acquired in the outpatient setting after major elective spine surgeries and to compare this with a hospital cohort of patients of the same surgeon. We excluded patients younger than 18 years old, all acute traumatic cases from this study as well as patients with previous spine surgery, minor procedures including, epidural steroid injections, discograms and laser rhizotomies (total 1195). Standard aseptic techniques were maintained throughout each operation at all centres which were either Joint Commission for the Accreditation of Health Organizations (JCAHO) or Agency for Health Care Administration (AHCA) compliant in addition to standard prophylactic antibiotics. Major operations included were anterior cervical discectomy and fusion, cervical disc arthroplasty and lumbar decompression with or without fusion procedures (total 1010). Of the 1010 patients included in this study, 642 were operated on in the hospital setting (Group 1) and 368 in the ASCs setting (Group 2). Selection criterion for outpatient spine surgery (28) are summarized in Fig. 1.

1. Patient must be living or staying within 30 minutes of a hospital
2. BMI </= 42
3. All patients with chronic medical illnesses must be stable and be cleared by their family practitioner and/or specialist where applicable
4. Patients with a history of heart disease must be cleared through cardiologist evaluation including echocardiogram and/or stress test
5. Patients must have a responsible adult living with, or staying with them, who is available to provide basic care and supervision for at least 24 hours after surgery
6. Low-to-moderate anaesthesia risks (ASA Criteria 1 to 3)

Fig 1: Inclusion criteria for outpatient spine surgery used in this study
BMI; Body mass index

Outcome measures evaluated were; age, BMI, length of surgery (LOS), estimated blood loss (EBL), presence or absence of both superficial and deep wound infections postoperatively and comparison of incidence in single and multilevel procedures. Risk factors evaluated included: age > 65 years (29–31), gender (32), smoking status (29), alcohol use (29, 31), BMI > 30 kg/m^2 (33) and incidence in multilevel surgery [34] (Table 1).

Statistical analysis

Statistical analysis was performed using SPSS v22 (IBM corporation, New York, USA). An independent sample student *t*-test was used to compare groups for continuous data and Pearson's Chi-squared or Fisher exact test used categorical data. Continuous data comparisons were expressed as means with standard error. Relative risk (RR) and 95% confidence intervals (95% CI) were calculated for each of the categorical variables using univariate and multivariate analysis. Tests were considered significant if $p < 0.05$.

RESULTS

A total of 1010 patients were evaluated. Group 1 comprised of 642 patients in the hospital setting and Group 2 comprised of 368 patients in the ASC. Females represented 52% of patients overall, however, there was no statistical difference in gender between groups, $p = 0.147$. Overall age and BMI was 53 ± 0.5 years and 28.3 ± 0.3 kg/m^2, respectively. Mean age of Group 1 was 54 ± 0.6 years and Group 2 was 50 ± 0.9 years ($p = 0.270$). Mean BMI for Groups 1 and 2 were 28.1 ± 0.3 kg/m^2 and 28.8 ± 0.4 kg/m^2, respectively, $p = 0.724$. Demographic data are presented in Table 1.

Table. 1: Demographic data of sample population

Age	**n = 1010**	**Percentage**	**Gender**	**n = 1010**	**Percentage**
18–39	334	33%	Male	485	48%
40–64	450	45%	Female	525	52%
> 65	220	22%			
BMI	n = 1010		Alcohol	n = 1010	
Underweight < 18.5	71	7%	Yes	586	58%
Normal 18.5–24.9	293	29%	No	424	42%
Overweight 25–29.9	323	32%	Smoking	n = 1010	
Obese 30–34.9	202	20%	Yes	576	57%
Morbid obese > 35	121	12%	No	434	43%
Number of levels	n = 1010				
Single level	551	55%			
Multilevel	459	45%			

BMI; Body mass index

Analysis of Groups 1 and 2 surgical times of 217 ± 11 minutes and 117 ± 8 minutes, respectively, revealed a statistically significant ($p = 0.001$) decrease in the outpatient group operative times. This was also true for estimated blood loss, Group 1 resulting with 323 ± 33 mL lost and Group 2 with 73 ± 8 mL ($p = 0.001$).

Overall incidence of postoperative SSI in both settings was 16 patients (1.6 %). In total, 88% occurred in the hospital setting and 12% in an outpatient setting. There were significantly less SSIs in the outpatient setting, $p = 0.045$ as shown in Table 2. Of those, 75% were superficial and 25% were deep infections. One hundred per cent (4) of deep infections occurred in hospital cohort, ($p = 0.383$, Table 2).

Table: 2. Incidence of surgical site infection in each setting

	No SSI	SSI	Superficial	Deep
Hospital	628	14	10	4
Outpatient	366	2	2	0
p-value		0.045		0.383

SSI; surgical site infection

Comparing cervical and lumbar cases, analysis revealed significance ($p = 0.0001$) between setting and total cases performed, however, there was no significance in incidence of SSIs between settings (Table 3).

Table: 3. Demographic of cervical and lumbar cases in each setting with infection incidence

	Total cases		Infection	
Spinal segment	**Cervical**	**Lumbar**	**Cervical**	**Lumbar**
Hospital	204	438	5	9
Outpatient	202	166	0	2
p-value		0.0001		0.839

There was a total of 385 (60%) multilevel procedures performed in the inpatient group compared to 74 (20%) in the outpatient group. There was significance between the number of single level procedures *versus* multilevel procedures performed in each setting, $p = 0.0001$. Subgroup analysis of the number of levels operated on and SSIs revealed no significance, $p = 0.468$ (Table 4).

Table: 4. Demographic of single and multilevel cases in each setting with infection incidence

	Total cases		Infection	
Number of levels	Single	Multi	Single	Multi
Hospital	257	385	3	11
Outpatient	294	74	0	2
p-value		0.0001		0.468

Risk factor analysis included: age > 65 years, gender, if patient smokes, use of alcohol, obesity > 30 kg/m^2 and multilevel surgery. Smoking, alcohol use, obesity and multilevel surgery proved to be significant risk factors. Of note obesity and smoking were the highest RR factors, RR = 9.3 and 10.9, respectively. Findings are summarized in Table 5.

Table: 5. Risk factors for infection for spine surgery using univariate and multivariate analysis

Risk factors for infection	Relative risk	Confidence interval	*p*-value
Age > 65yeas	2.1	0.76–5.67	0.15
Gender (Male)	0.6	0.24–1.77	0.84
Smoker	10.9	1.44–82.13	0.02
Alcohol use	5.1	1.16–22.17	0.03
Obesity > 30 kg/m^2	9.3	2.65–32.41	0.005
Multilevel surgery	5.2	1.5–18.14	0.01

The most common organism identified by culture and sensitivity was *Staphylococcus aureus* in 13 patients (hospital cohort 12, outpatient 1). The other three patients had growth < 105 organisms. All superficial infections were treated with opening of the wound and healing by secondary intention whereas, all cases with deep infections had reoperation with implant removal.

DISCUSSION

This study aimed to directly compare the incidence of SSIs after spinal surgery in both the hospital and ambulatory surgery centre settings. Overall, there was a statistically significant difference in the incidence of SSIs occurring postoperatively between cohort groups. Superficial infections were more common than deep infections, which only occurred in the hospital group. This may be attributed to the significant decrease in operative time and blood loss in the outpatient group. Obesity, alcohol use and multilevel surgery were statistically significant risk factors and patients who smoked had the highest significant relative risk.

Surgical site infections are a major cause of morbidity and mortality for patients and are economic burden on the healthcare system (35, 36). It is important for surgeons to be aware of the risk factors, with the increasing number of ambulatory surgery centres offering outpatient spine surgery.

General classification of SSIs is divided into superficial, involving the skin incision and subcutaneous tissue and deep infections (37, 38). Clinical presentation for superficial infections involves pain, local tissue oedema and oozing of serosanguinous material, warmth, erythema and tenderness and usually occurs within two weeks of surgery. Deep infections may present similar to superficial over but usually develop after approximately six weeks to several months postoperatively.

The determination of SSI risk and risk factors has two important applications. First, accurate quantification of SSI risk is needed to compare SSI rates between patients groups. This can be determined by the setting of the operation, the service offered and the individual surgeon. Second, determining SSI risk for an individual patient is necessary to gauge the potential utility of preventive interventions (39).

Obese patients are at risk of having tissue necrosis in sutured wounds due, to an extensive layer of relatively avascular adipose tissue, which create a nidus for infection (40). Obesity has been shown to be an independent risk factor for both superficial and deep infections in previous studies (30, 35). The authors therefore advocate that, especially for outpatient spine surgery, a formal weight-loss programme should be in place for these patients as part of their management (35, 41) or patient selection be based on a predetermined eligibility criteria used (28, 42).

Although advanced age (43, 44) is believed to be a risk factor for SSI due, to the phenomenon of immunosenescence, whereby the body's immune system weakens with age, our study did not show a significant difference in age as a risk factor for SSI. However, for the purposes of ambulatory spine surgery, the authors advocate for surgery in patients' ages 18–80 years once they are deemed healthy and medically cleared by their primary care physician.

There is evidence to suggest that in a hospital setting, the incidence of postoperative infection of the lumbar intervertebral disc space is reduced, the less invasive the procedure (45). There is minimal evidence evaluating number of levels in a single procedure however, our study supported study by Ee *et al* (34), demonstrating that multilevel surgery is a risk factor for SSIs. Surgical site infections in multilevel procedures occurred at an incidence rate of 81% (13/16) compared to single procedures at 19% (3/16).

The use of surgical drains post spine surgery has been previously advocated to decrease wound complications (46–48). However, evidence-based guidance (49) as well as evidence showing a decrease in this rate once less exposure surgery techniques (28, 34, 50) which limit dead space and the potential haematoma formation were instituted has led to a decline of this practice. No patients in the outpatient centre who had lumbar decompression with or without fusion had a lumbar drain *in situ*.

Several solutions have been proposed and tested to eliminate or at least reduce the incidence of this crippling complication such as ultra-clean airflow system, antibiotic-loaded allografts and standardizing prophylactic antibiotics (51–54). However, the most important modifiable risk factors identified in the literature inclusive of BMI, glycaemic control, smoking, alcohol abuse, duration of surgery and repeat surgery as part of staged procedures must be a prime target for surgeons operating in the ASC as the risk to the patient, surgeon and institution is magnified since patients are typically discharged within 24 hours of surgery, which may delay diagnosis and treatment of a developing SSI.

The authors report no biases or conflict of interest. The authors note the following strengths and limitations. The main strengths of this study are; sample size, random selection of patients based on inclusion criteria. The outcomes assessed include, patient and surgeon factors which were independently analysed. The variable of multiple surgeons was also controlled for since it was a single surgeon study.

Limitations of this study, which include: (1) a retrospective study (2) the absence of evaluation of patient metabolic factors before and after surgery, which are known to contribute to postoperative infection. Examples of these include poor nutritional status, as determined by serum albumin levels < 35 g/dL and glycaemic status of diabetics in the study, (3) we did not consider medications known to impair wound healing such as steroids and those which hinder fusions such as NSAIDS, (4) the operating room used in both the hospital and outpatient groups varied although compliant and (5) baseline white blood cell counts were within range for preoperative assessment however, no postoperative analysis was performed. It would also be interesting to do follow-up prospective studies on SSIs in ambulatory centres.

In the outpatient setting, the authors recommend strict patient selection, extensive pre-operative counselling and explanation of the possibility for SSI in high-risk patients w ho failed to adequately modify their lifestyle through alcohol, smoking cessation, weight-loss and blood sugar control. From a surgeon's perspective, limiting the number of fusion levels, mandating strict aseptic techniques by all staff members (40, 55), ensuring prophylactic antibiotics, adopting instruments and surgical techniques which promote less exposure surgery, can all contribute to lowering the incidence of SSI after spine surgery in the ambulatory surgery centre.

CONCLUSION

The healthcare arena continues to expand with outpatient services being offered. This study has demonstrated a reduced incidence of SSIs in the outpatient setting compared to the hospital setting. Patients with risk factors such; as smoker, alcohol use and obesity should be carefully assessed to decrease this risk.

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